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Code Ident OEEH4
20 January 1989

**INTERFACE SPECIFICATION
SPACE SEGMENT TO GROUND SYSTEM
OF THE
DEFENSE METEOROLOGICAL SATELLITE PROGRAM**

In Response to
Contract F04701-89-C-0102
CDRL Item 034A2

20 January 1989

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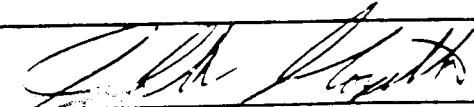
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16 TECHNICAL CONCURRENCE				DATE

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INTERFACE SPECIFICATION
between the
SPACE SEGMENT TO GROUND SYSTEM
of the
DEFENSE METEOROLOGICAL SATELLITE PROGRAM

Signature

Date

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Approval

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1.0 SCOPE

1.1 Item description

1.1.1 Purpose: This Interface Specification defines the interface between the Space Segment and Ground System of the Defense Meteorological Satellite Program (DMSP) for Block 5D-2 and 5D-1 era satellites. The Space Segment is composed of satellites along with their Aerospace Support Equipment (ASE) and Ground Support Equipment (GSE). The Ground System consists of the User Segment (US) and the Command, Control and Communications Segment (C3S). A functional overview of the interrelationship of the Ground System and the Space Segment is illustrated in Figure 1-1.

| 001

1.1.2 Overview of DMSP specifications A specification tree describing the relationship of this specification to other top level DMSP specifications is provided in Figure 1-2. As shown, DMSP-300 is the system specification, under which there are three main segment specifications: SS-YD-860 for the Space Segment, SS-YD-855 for the User Segment, and SS-YD-854 for the C3S. The SCF-100 defines the interface between the C3S and the Consolidated Space Test Center (CSTC) which is part of the AFSCN. The interface between the C3S and the DMSP US is controlled by the IS-YD-861 Interface Specification.

AF AIR FORCE
 AFGWC AIR FORCE GLOBAL WEATHER CENTRAL
 AFSCN AIR FORCE SATELLITE CONTROL NETWORK
 AFVSF ADVANCED FLIGHT VEHICLE SIMULATION FACILITY
 ARTS AUTOMATED REMOTE TRACKING STATION

C³ COMMAND, CONTROL & COMMUNICATIONS
 CSOC CONSOLIDATED SPACE OPERATIONS CENTER
 CSTC CONSOLIDATED SPACE TEST CENTER

DOMSAT DOMESTIC COMMUNICATIONS SATELLITE
 DMSP DEFENSE METEOROLOGICAL SATELLITE PROGRAM

FNOC FLEET NUMERICAL OCEANOGRAPHY CENTER
 FSOC FAIRCHILD SATELLITE OPERATIONS CENTER

GE/ASD GE ASTRO SPACE DIVISION GROUND SUPPORT EQUIPMENT

HTS HAWAII TRACKING STATION
 MC MARINE CORPS
 MPSOC MULTI PURPOSE SATELLITE OPERATIONS CENTER

NHS NEW HAMPSHIRE TRACKING STATION

PTF PAYLOAD TEST FACILITY
 RTS REMOTE TRACKING STATION
 TTS THULE TRACKING STATION
 VTS VANDENBERG TRACKING STATION

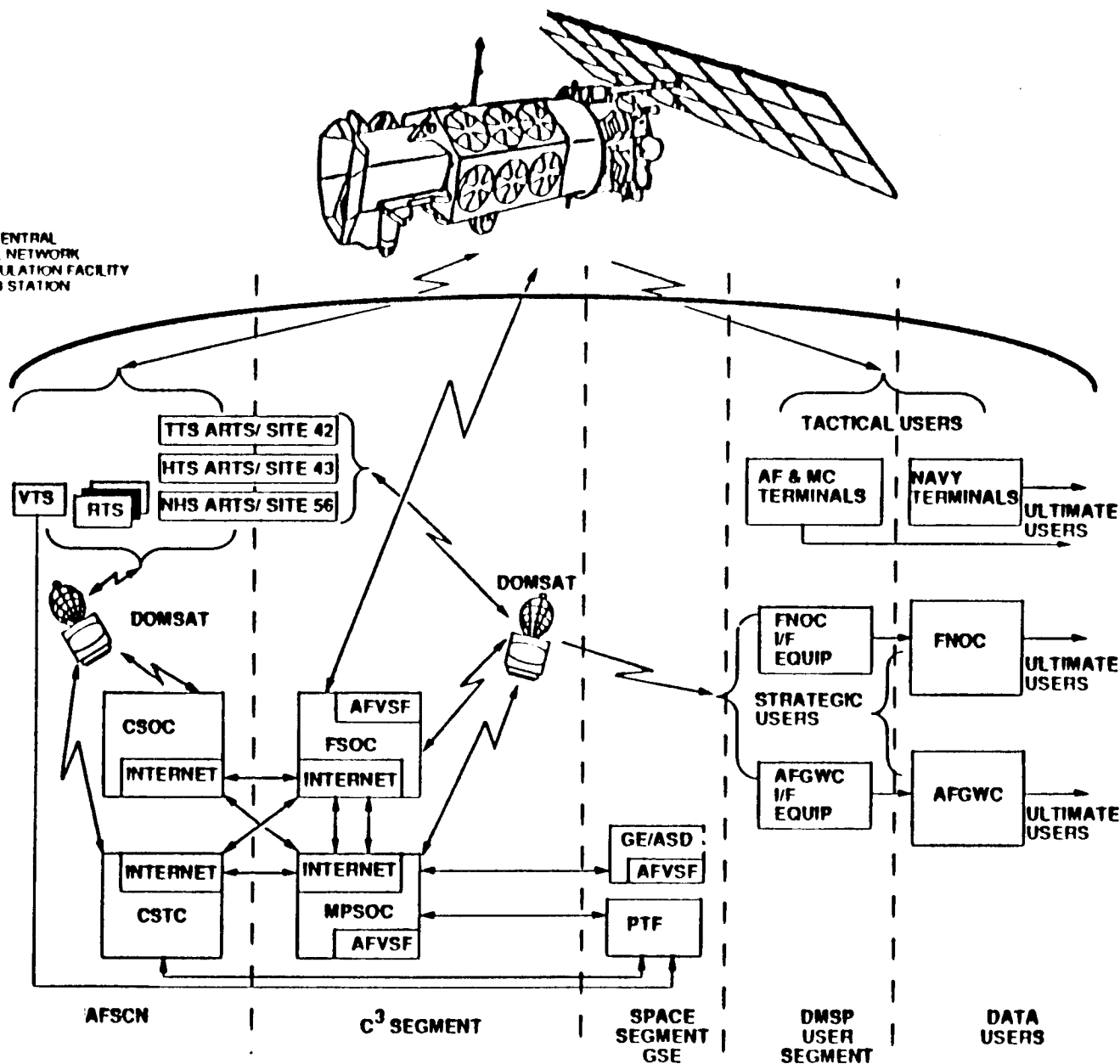


FIGURE 1-1. DMSP COMPONENT SEGMENTS

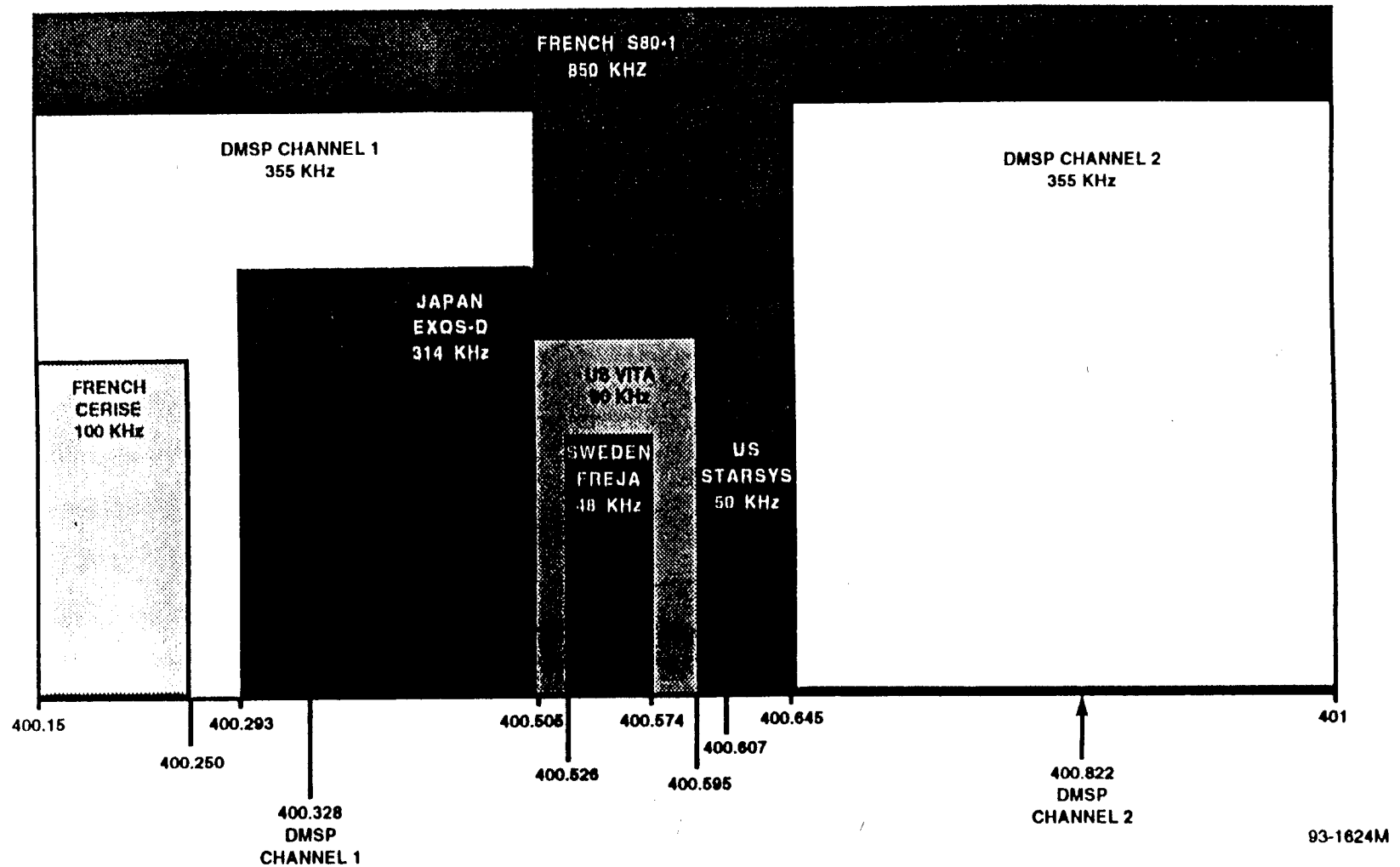


Figure 1. Frequency-Sharing Plan for Users of the 400.15 to 401 MHz Frequency Band
(Courtesy of ECAC)

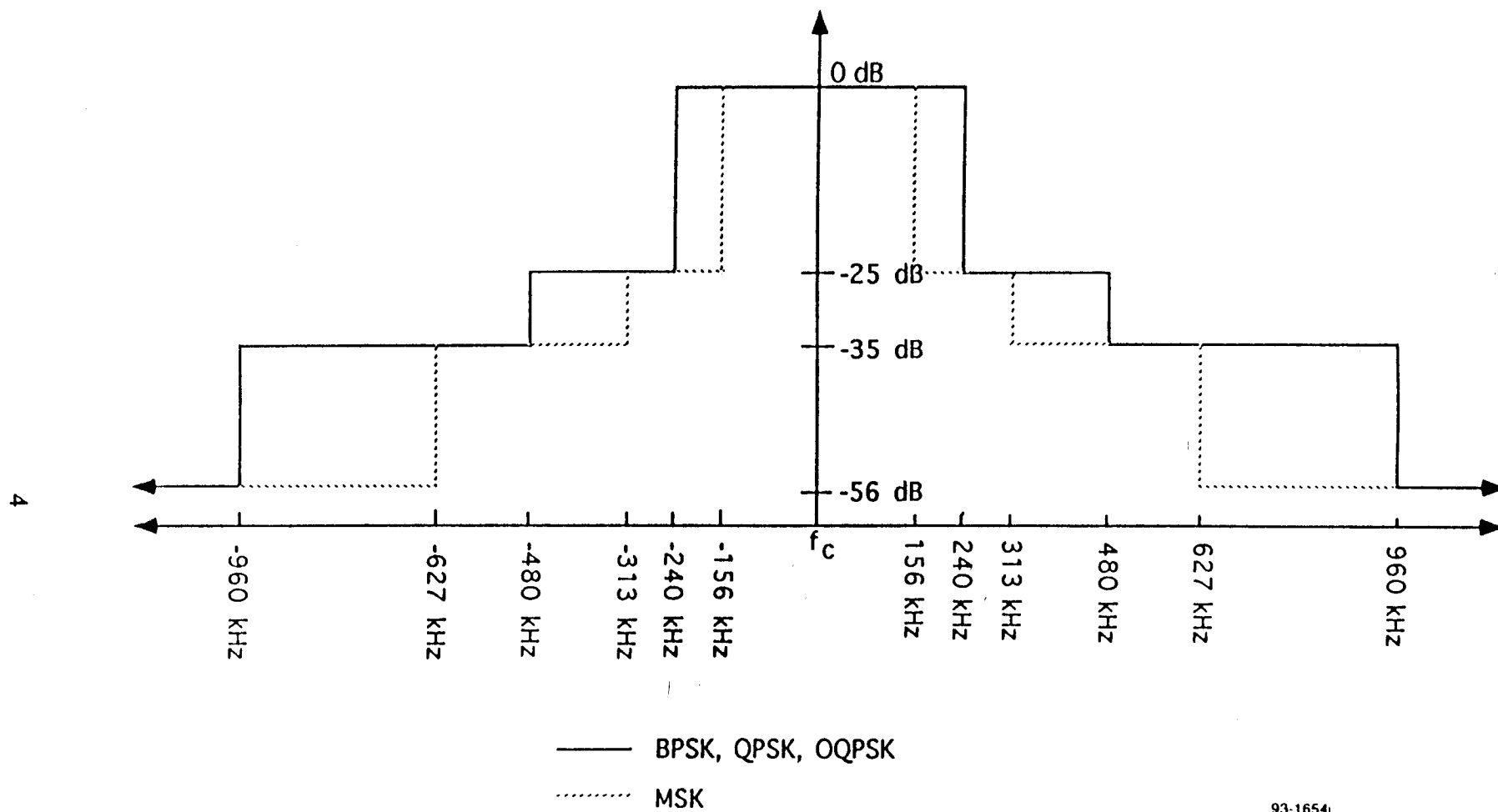


Figure 2. NTIA Emission Bandwidth Requirements

2.0 TECHNICAL

2.1 MODULATION SCHEMES CONSIDERED

The following sections describe in some detail the various modulation schemes considered and their potential as solutions to the 400.15 to 401 MHz band frequency compatibility issue. The four modulation schemes considered in this study are BPSK, Quadrature Phase-Shift Keying (QPSK), Offset QPSK (OQPSK), and Minimum Shift Keying (MSK). These have been chosen for study because they are all power efficient, which is critical in this application. One thing that is common among the approaches is that no matter which approach is used, filtering would need to be employed in order to meet the NTIA emission bandwidth requirements.

The filtering issue becomes a difficult one due to the low data rate of the baseband signal. There are three possible locations where a filter could be employed, and these are shown in Figure 3. These options are discussed in the following paragraphs.

Pre-Modulation Filter. This is the only truly feasible option, and thus is the location where filtering will be done. Filtering of OQPSK or MSK at this location will enable compliance with the NTIA requirements. This option cannot be used with BPSK or QPSK because with operation of the amplifier in a saturated condition, regeneration of the filtered signal occurs. This regeneration completely offsets the function of the filtering. Spectral plots and bit error rate curves were generated for each of the studied modulation schemes with three separate filter roll-off characteristics. These plots are presented later in this section.

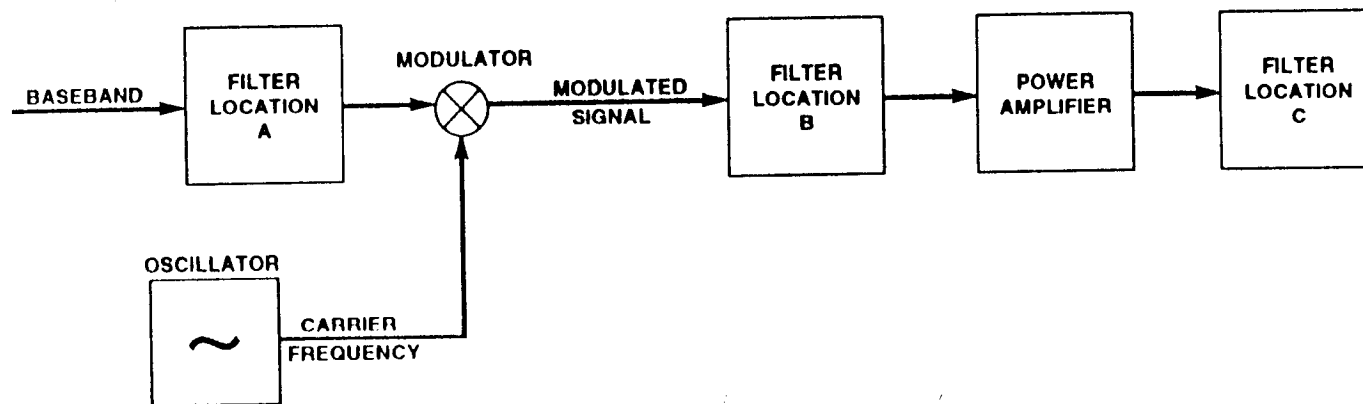
Post-Modulation, Pre-Amplification Filter. Regeneration of the filtered signal once again rules out BPSK and QPSK for this approach. Filtering here is also not an inviting option with Offset QPSK or MSK. Achievement of a feasible filter design is close to impossible due to the low data rate, which results in appreciable loss (15 to 20 dB), and causes a very large and heavy filter.

Post-Amplification Filter. This option is the most difficult of all. Again, a high Q filter must be used. The filter will be extremely lossy (15 to 20 dB), very large and heavy, and might require temperature compensation. Because the signal has already been amplified, a high loss cannot be tolerated in the link.

2.1.1 FILTERED BPSK AND QPSK

It is a well-known phenomenon that much of the $\sin x/x$ spectrum is regenerated when filtered BPSK or QPSK modulated carriers pass through a saturated amplifier. Filtering of BPSK and QPSK causes considerable amplitude variations in the carrier envelope. The limiting characteristics of the saturated amplifier take out these amplitude variations, thus approximately regenerating the original, unfiltered modulated waveform. Figures 4 and 5 show the regeneration of BPSK and QPSK, respectively. The software used to produce the data shown in these figures and throughout this report is Comdisco System's Signal Processing WorkSystem (SPW). It is a digital signal processing program running on a SUN Spare10 workstation. The extensive communication system library and powerful computation tools make SPW the ideal software to use for this study.

One standard measure of the frequency space filled by a signal is "occupied bandwidth," which is defined here as the bandwidth that contains 99% of the signal's energy. Unfiltered 177 kbit/s BPSK and QPSK have an occupied bandwidth of 3664 KHz and 1832 KHz, respectively. The bandwidth could be reduced significantly with a filter if there were no limiting amplifier in the transmitter. Figures 6 and 7 show the effect of the RDS UHF saturated amplifier on occupied bandwidth for BPSK and QPSK, respectively. The filter used is a root raised cosine filter at various roll-off values with an $x/\sin x$ equalizer. The frequency response of the filters used in the



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Figure 3. Filter Location Options

3.0 INTERFACE REQUIREMENTS DMSP's space-to-ground interfaces for its uplink and downlinks consist of four generic types of interfaces. These interface types are the radio frequency or Ether, Cryptographic, Data Format and Data Content Interfaces. Each is applicable to the complete data processing streams, from the Space Segment through the Ground System, for Stored Data, Direct (Real-Time) Data, Equipment Status Telemetry, Command Verification and Uplink Commanding. These processing streams, with the interface types identified, are depicted in Figure 3-1. The indirect interfaces indicated with dashed lines identify paired functions between the space and ground systems.

- a. Ether (Radio Frequency) Interface. This is the direct physical interface between the satellite on orbit and the ground system resources. The radio frequency (RF) interface requirements specified in IS-YD-812 include carrier and subcarrier frequency characteristics, modulation characteristics and the minimum effective isotropic radiated power.
- b. Cryptographic (Crypto) Interface. This interface is an indirect, functional interface between satellite and ground system equipment. The RF interface should be considered transparent to the crypto interface. This crypto interface exists only for those specific DMSP satellites, or portions thereof, protected by cryptographic equipment. This type of functional interface must be implemented in order to successfully transmit/receive data.

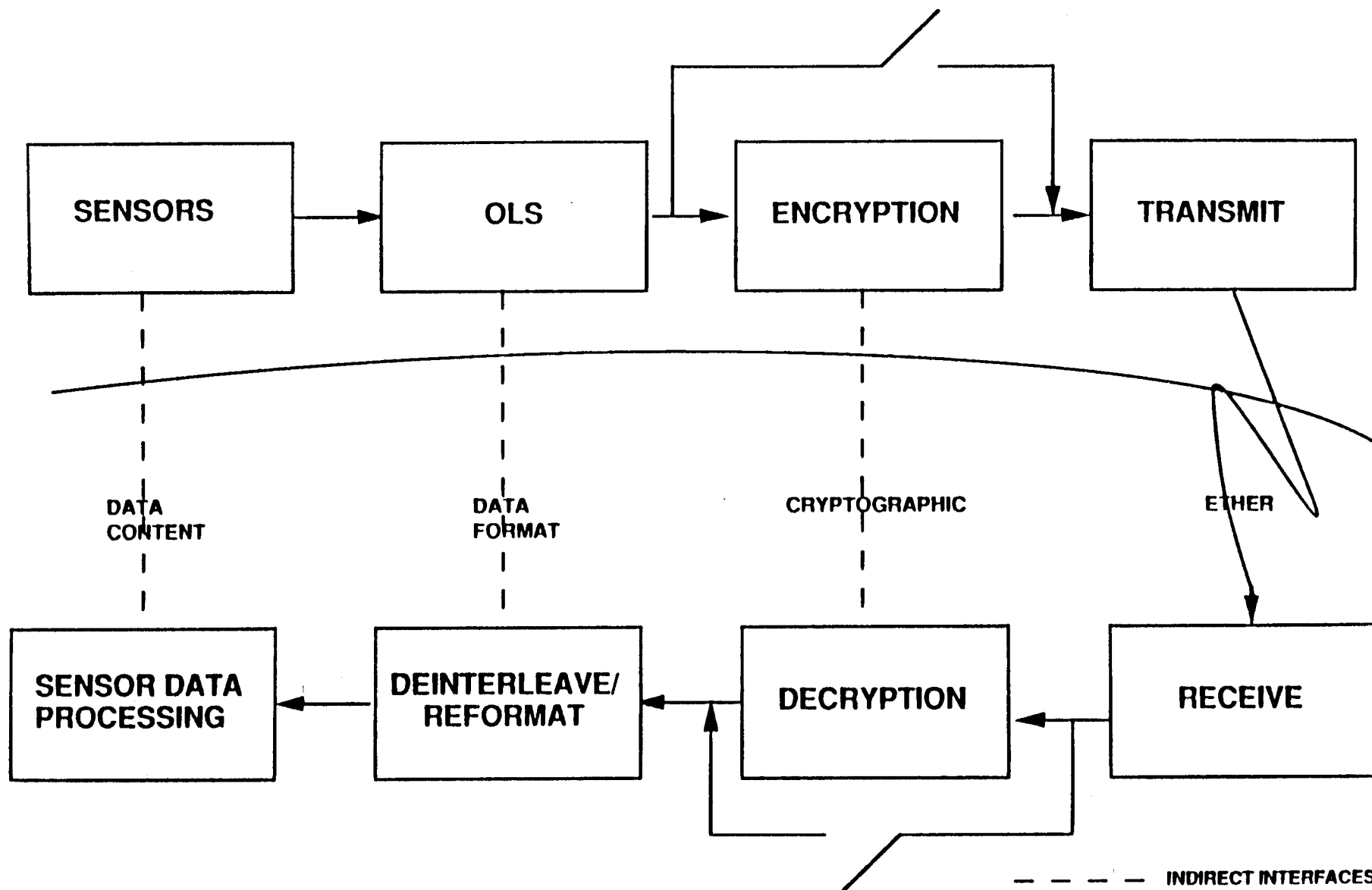


FIGURE 3-1. SPACE-TO-GROUND INTERFACES, STORED DATA PROCESSING
(SHEET 1 OF 5)

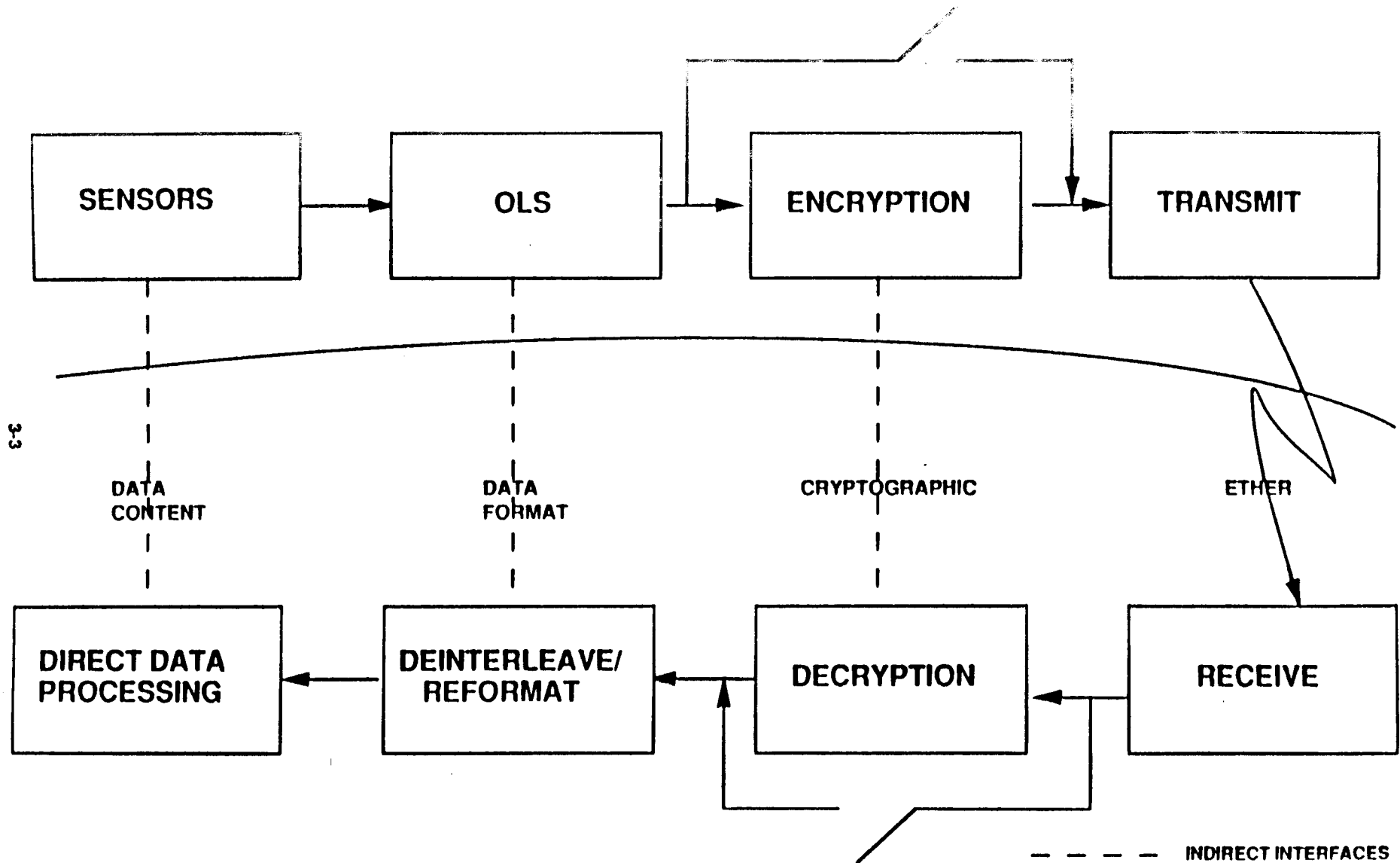
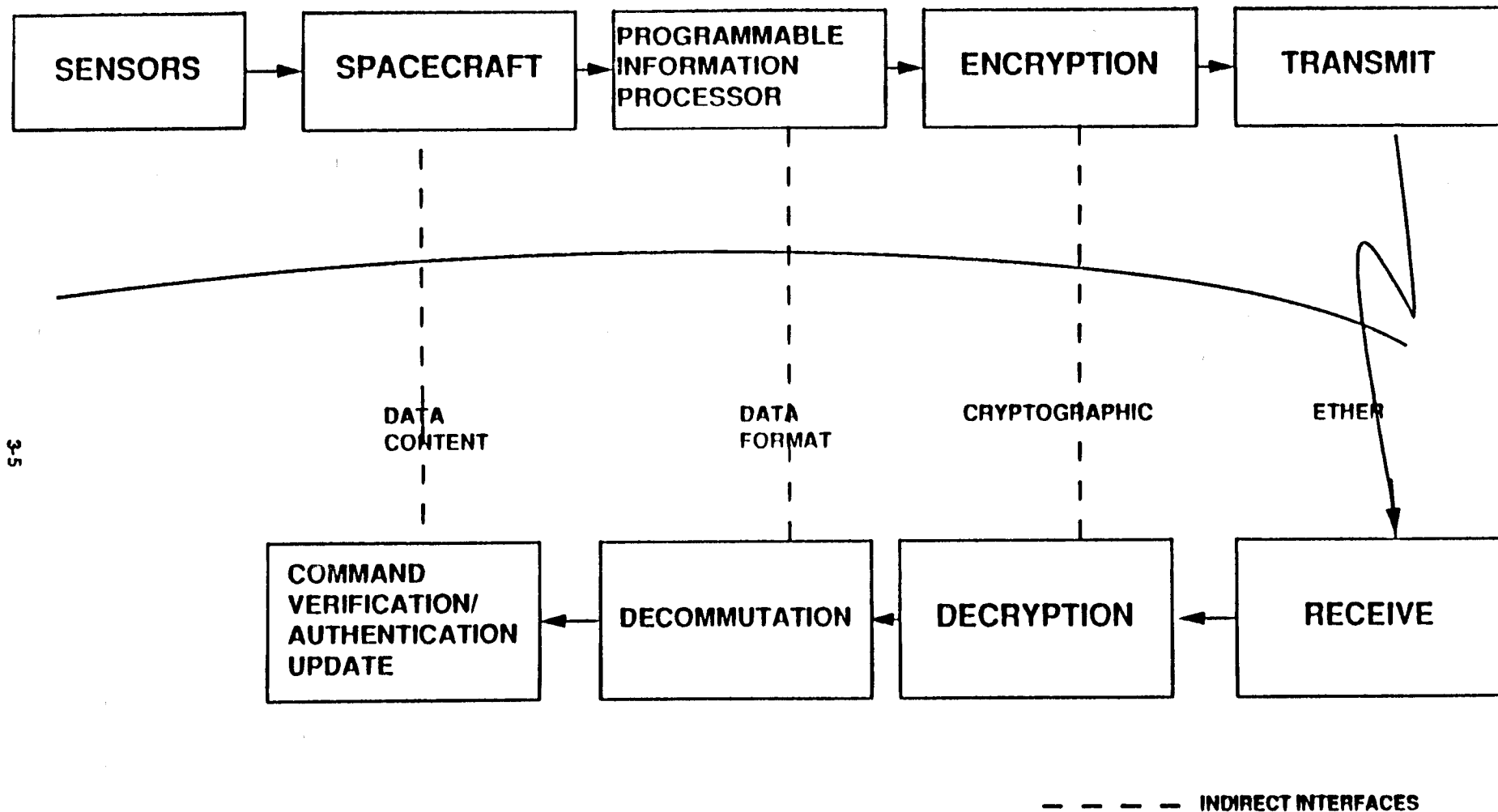


FIGURE 3-1. SPACE-TO-GROUND INTERFACES, DIRECT DATA PROCESSING
(SHEET 2 OF 5)



**FIGURE 3-1. SPACE-TO-GROUND INTERFACES, COMMAND VERIFICATION
(SHEET 4 OF 5)**

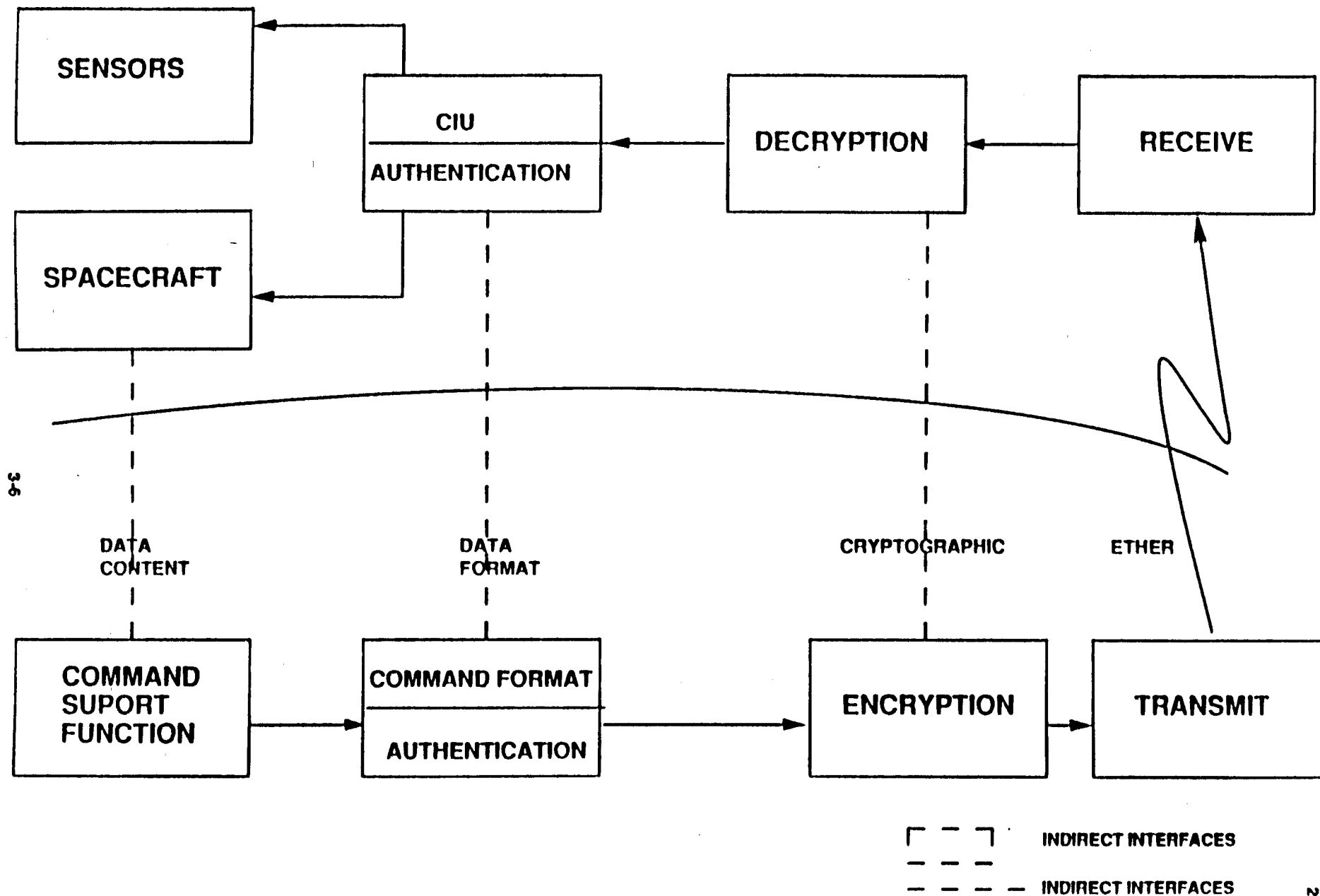


FIGURE 3-1. SPACE-TO-GROUND INTERFACES, COMMANDING
(SHEET 5 OF 5)

- c. Data Format Interfaces. These are also indirect, functional interfaces between satellite and ground system equipment and refer primarily to the data multiplexing scheme used for any particular link. The RF and crypto interfaces should be considered transparent to the data format interfaces.
- d. Data Content Interfaces. These indirect, functional interfaces are the final interfaces between satellite and ground system equipment. The RF, crypto, and data format interfaces should be considered transparent to the data content interfaces. Examples include specific parameter assignments to data format slots, parameter calibration, command lists, detector sensitivities, etc. These interfaces provide the detailed engineering information required to understand the meaning of specific data types.

These interfaces are controlled primarily through a series of specifications or ICDs, written by the contractor principally responsible for the area. The documents are illustrated in Figure 3-2 which also shows the AFSCN and the encryption/decryption (KG) interface control documents. The KG interface/documentation is not controlled by DMSP. It is not intended that this document require frequent modification. The replacement of spacecraft components/sensors or ground system components with similar units should not require changes to this document.

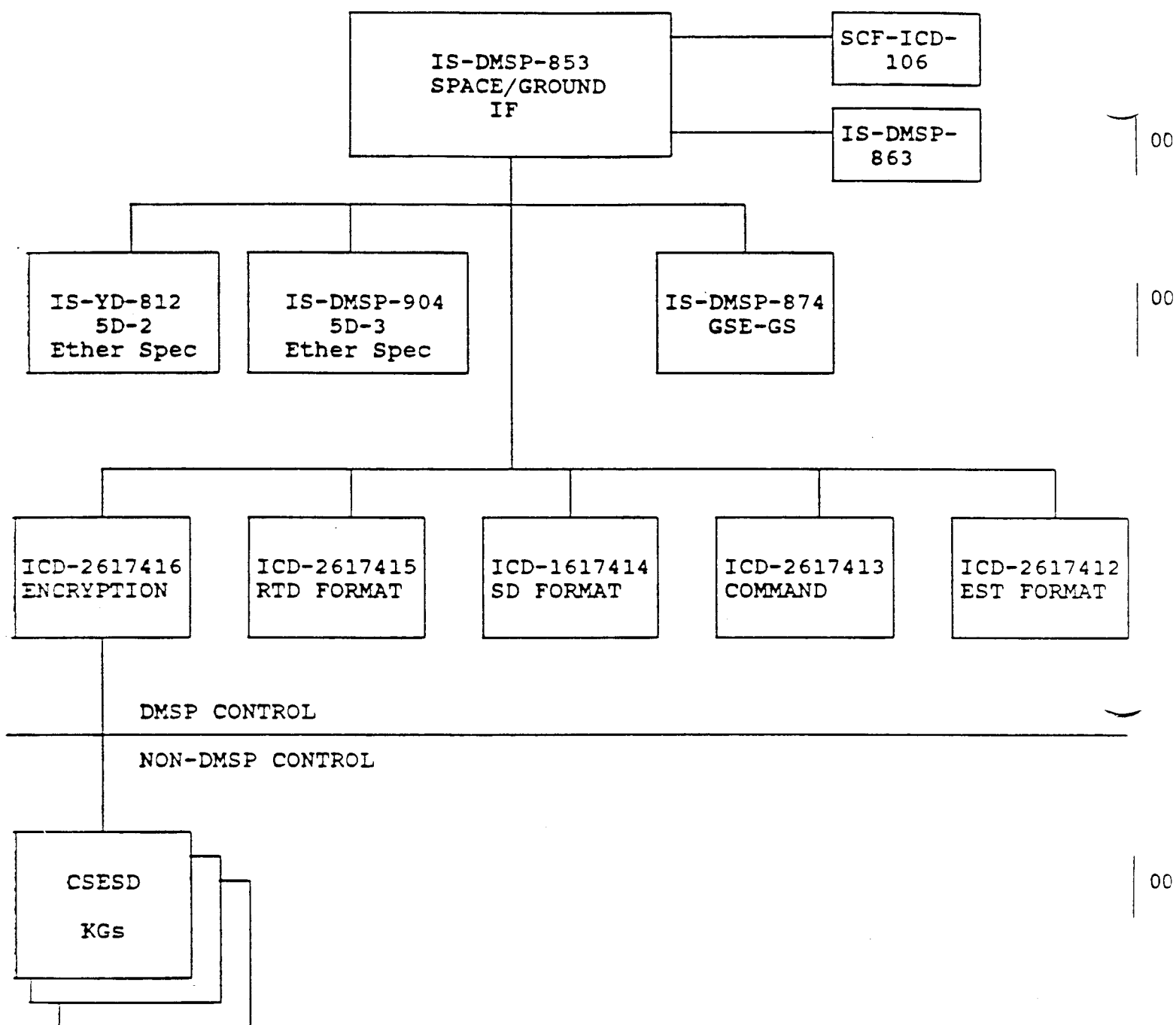


FIGURE 3-2. INTERFACE CONTROL TREE

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3.1 Physical Requirements. Direct interfaces between the Space Segment and Ground System consist of the operational radio frequency (RF or Ether) spacecraft to ground system data links, including modulation scheme, and Ground System to Ground Support Equipment communications interfaces.

3.1.1 RF Interface Requirements. The RF interfaces between the satellite and Ground System resources service the Equipment Status Telemetry (EST) downlink, Stored Data (SD) downlink, Real-Time Data (RTD) downlink, and the Commanding (CMD) uplink. Each downlink may use one of several different physical spacecraft transmitters depending on operational requirements. The DMSP downlink and uplink channels shall conform to the Space-Ground Link Subsystem (SGLS), as described in Aerospace TOR-0059. The uplink shall conform to SGLS channel 8. The stored data link shall conform to channels 2 and 14, realtime data to channel 11 and equipment status telemetry data to channel 8. Minor exceptions to satisfy the DMSP mission shall be generally specified in the appropriate ICDs to satisfy the DMSP mission. All RF interface requirements and individual transmitter characteristics are defined in the referenced Ether Interface Specification IS-YD-812 (through S-15) or IS-DMSP-904 (S16 through S20).

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3.1.2 Ground System to Ground Support Equipment Requirements
The interfaces between the Ground System and the Ground Support Equipment support the data links between the 1000th Satellite Operations Group and DMSP contractor Ground Support Equipment at locations including the Payload Test Facility, GE Astro Space Division and Westinghouse's Electronic Systems Division. All interface requirements and provisions are defined in IS-DMSP-874.

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3.2 Functional Interface Requirements. Functional interface requirements are discussed in terms of data stream formats and data content definitions for each interface. The DMSP data streams providing the links between the Space Segment and Ground System comply with several high level methodologies or techniques. They specify the data structure, link channel and data rates used.

3.2.1 Definitions

3.2.1.1 Data Stream Formats. The DMSP data streams are composed of many different types of data; including information from the Primary Sensor, Mission Sensors, Equipment Status Telemetry (EST) and Command Uplink/Verification. There is a nested series of "formats" associated with the process of combining these data types into any of the several specified DMSP data superframe and/or frame structures. The concept of what is part of a DMSP data stream is illustrated in Figure 3-3. For the purpose of this document, format is restricted to mean the high level superframe or frame structure available from the Operational Linescan System (OLS), the Programmable Information Processor (PIP) or the Command Uplink.

For the telemetry data from the PIP, the addition or deletion of telemetry channel assignments is not considered a format change. Format changes include different data rates and changes to superframe or frame architecture. These types of format changes may have large impacts on either the Space Segment or the Ground System and should be carefully controlled.

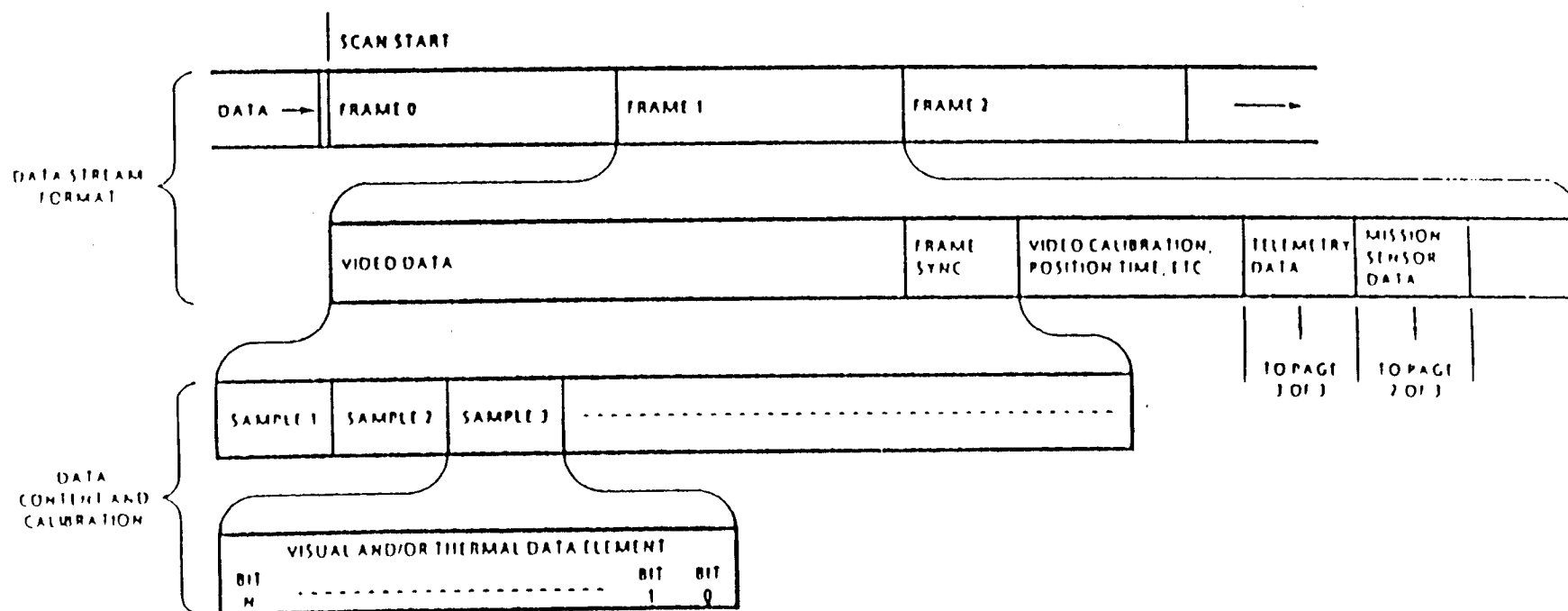


Figure 3-3 Illustration of DMSP Data Format/Data Content, Stored or Real-Time OLS DATA
(Sheet 1 of 3)

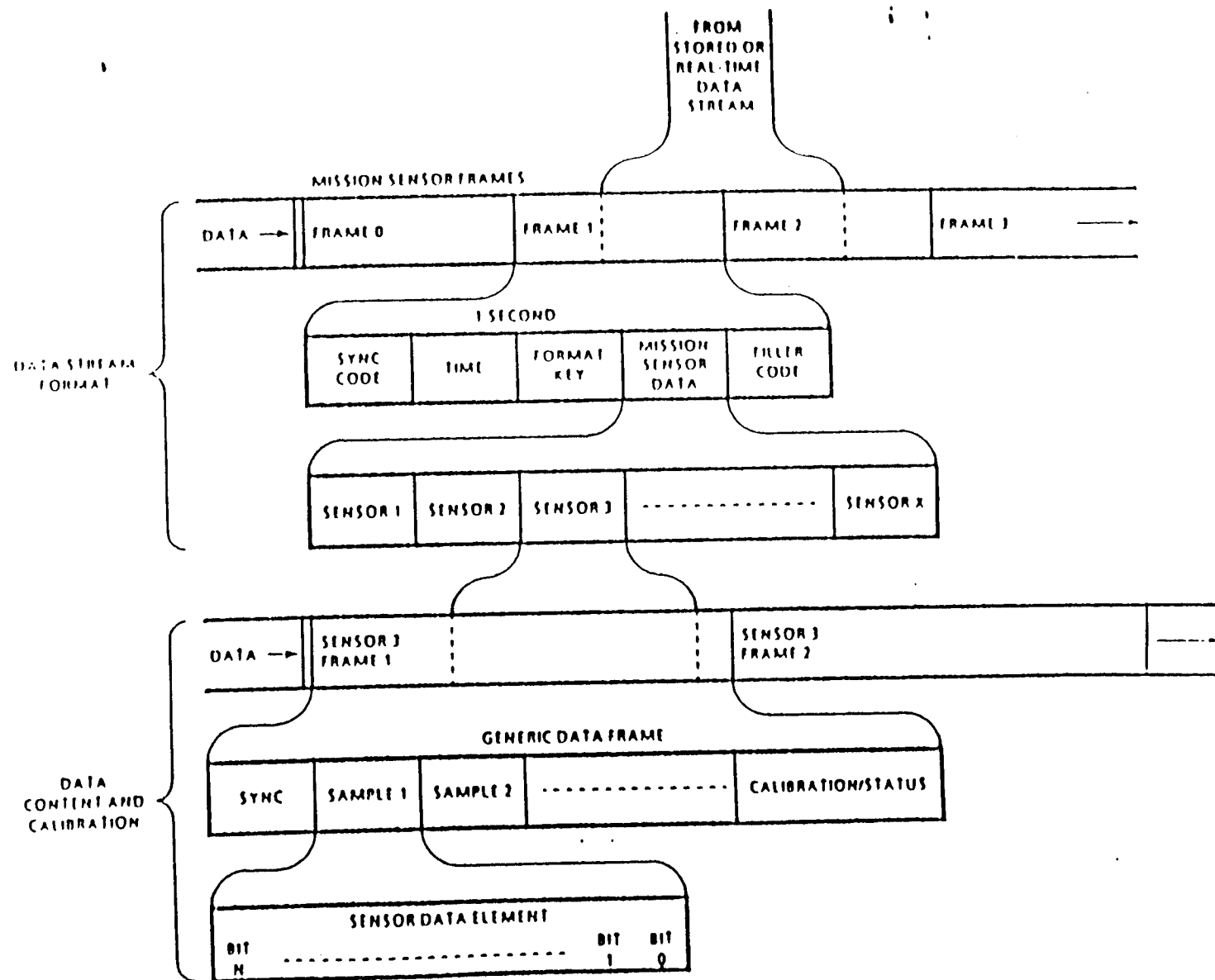


Figure 3-3 Illustration of DMSP Data Format/Data Content, Mission Sensor Data
(Sheet 2 of 3)

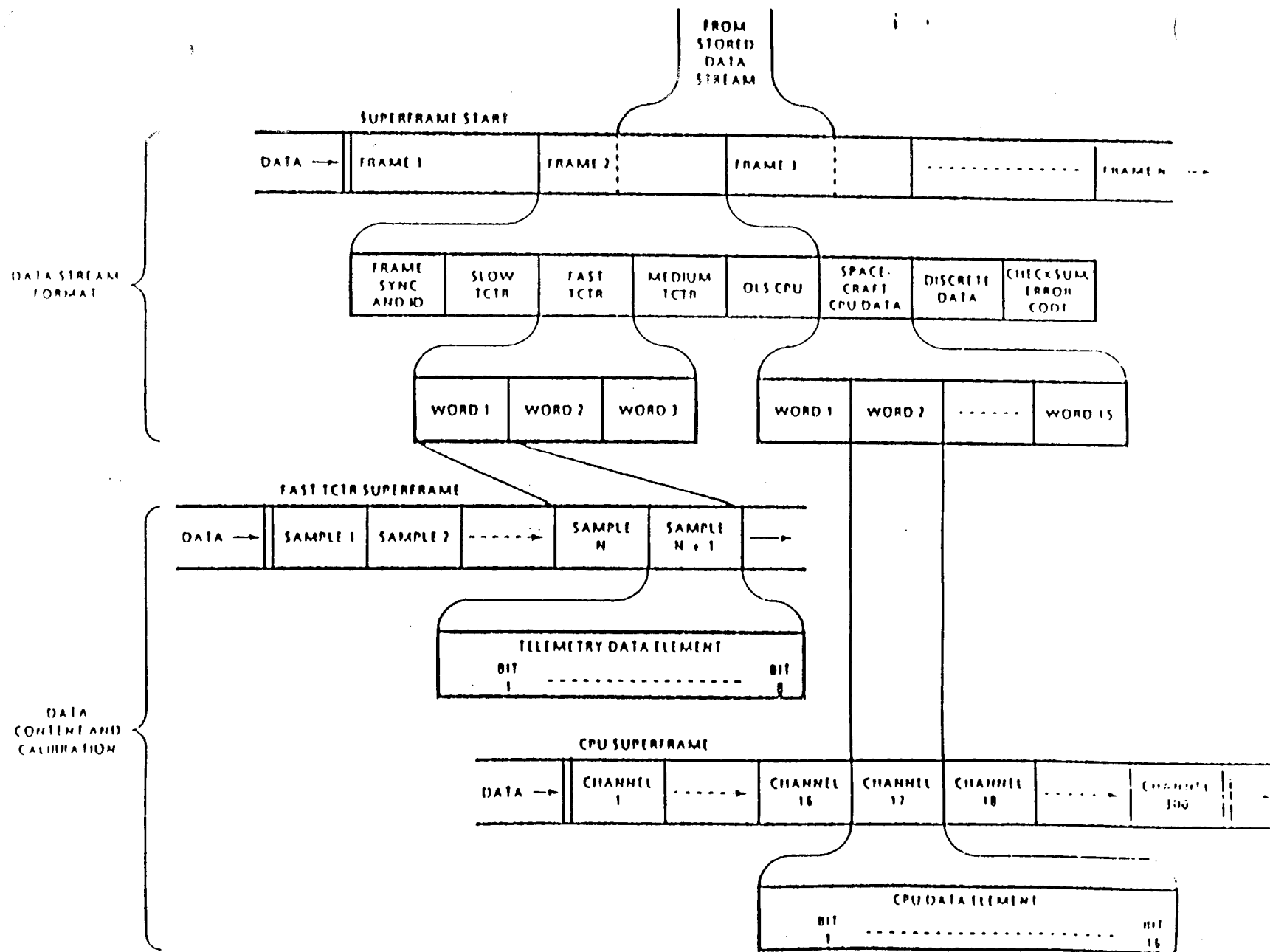


Figure 3-3 Illustration of DMSP Data Format/Data Content, Equipment Status Telemetry
(Sheet 3 of 3)

3.2.1.2 Data Content Definition and Calibration. Data content definition covers the structure of the primary sensor, mission sensor and telemetry system data within the format data blocks. The data content includes bit weighting information and coefficients necessary to translate the data blocks into understandable parameters, such as voltages, currents, temperatures and brightness levels. The architecture or format of the mission sensor data is included with data content definition since it is a level below the decomposition of the data stream from superframes and/or frames.

The calibration data represents measured and/or calculated performance characteristics for a particular device or spacecraft. Some sensors and telemetry points do not require calibration data as a result of design or limited accuracy requirements. Final calibration data is typically not available prior to sensor final testing and/or spacecraft integration. It may not be available until after on orbit testing for some systems. Where calibration data is not required or available, the data content definitions should supply enough information to support integration and test activities.

3.2.2 Encryption/Decryption Interface Requirements.

3.2.2.1 Stored Data Requirements. All DMSP spacecraft shall have the capability to encrypt the SD links. An encryption bypass capability shall be provided for plain text transmissions. Space and ground resources encryption equipment interfaces are defined in Tables I and II. Further detail on requirements concerning interfaces with and between this equipment is provided in CSESD-8.

3.2.2.2 Real-Time Data Requirements. All DMSP spacecraft shall have the capability to encrypt the RTD links. An encryption bypass capability shall be provided for plain text RTD transmissions. Space and ground resource encryption equipment interfaces are defined in Tables I and II. Further details on requirements concerning interfaces with and between this equipment is provided in CSESD-8.

3.2.2.3 Satellite Commanding Requirements. Beginning with Spacecraft 9, the command link shall be encrypted and authenticated. Prior spacecraft have no such requirement. Space and ground encryption/authentication equipment interfaces are defined in Tables I and II. Further details on requirements concerning interfaces with and between this equipment is provided in ICD-2617416 and in CSESDs 17, 7, and 33.

TABLE 1 ENCRYPTION/DECRYPTION AND AUTHENTICATION SPACE CRAFT INTERFACES

DATA LINES SPACECRAFT	EQUIPMENT STATUS TELEMETRY COMMAND VERIFICATION ENCRYPTION	COMMAND AUTHENTI- CATION DECRYPTION	STORED DATA ENCRYPTION	REAL-TIME DATA ENCRYPTION
SPACECRAFT 6 FLIGHT 6	N/A	N/A	KG-43	KG-43
SPACECRAFT 7 FLIGHT 7	N/A	N/A	KG-43	KG-43
SPACECRAFT 8 FLIGHT 9	N/A	N/A	KG-43	KG-43
SPACECRAFT 9 FLIGHT 8	KG-46	KG-57/ HS-57	KG-43	KG-43
SPACECRAFT 10 FLIGHT TBD	KG-46	KG-57/ HS-57	KG-43	KG-43
SPACECRAFT 11 FLIGHT TBD	KG-46	KG-57/ HS-57	KG-43	KG-43
SPACECRAFT 12 FLIGHT TBD	KG-46	KG-57/ HS-57	KG-43	KG-43
SPACECRAFT 13 FLIGHT TBD	KG-46	KG-57/ HS-57	KG-43	KG-43
SPACECRAFT 14 FLIGHT TBD	KG-46	KG-57/ HS-57	KG-43	KG-43
SPACECRAFT 15 FLIGHT TBD	KG-46	KG-57/ HS-57	KG-43	KG-43

TABLE 3-2 Encryption/Decryption and Authentication Ground Equipment Interfaces

GROUND EQUIPMENT	DATA LINKS	EQUIPMENT STATUS TELEMETRY COMMAND VERIFICATION	COMMAND AUTHEN- TICATION/ ENCRYPTION	STORED DATA DECRYPTION	REAL-TIME DATA DECRYPTION
AFSCN		KGR-62	KGT-61	N/A	N/A
MX II/III TACTICAL TERMINALS		N/A	N/A	N/A	KG-44
MX IV TACTICAL TERMINALS		N/A	N/A	N/A	KG-44
NAVY SMQ-18		N/A	N/A	N/A	KG-44
NAVY SMQ-11		N/A	N/A	N/A	KG-44
AFGWC		N/A	N/A	KG-44	N/A
FNOC		N/A	N/A	KG-44	N/A
MPSOC		KGR-61	KGT-61	KG-44	N/A
FSOC		KGR-61	KGT-61	KG-44	N/A
WEC		N/A	N/A	N/A	KG-44
ONOC		N/A	N/A	N/A	KG-44
GE FACTORY		KGR-28	KGT-29	N/A	KG-44
PTF		KGR-28	KGT-29	KG-44	KG-44

FSOC
MPSOC
AFSCN
AFGWC
FNOC
WEC
ONOC
PTF

- FAIRCHILD AFB SATELLITE OPERATIONS CENTER
- MULTI-PURPOSE SATELLITE OPERATIONS CENTER
- AIR FORCE SATELLITE CONTROL NETWORK
- AIR FORCE GLOBAL WEATHER CENTRAL
- FLEET NUMERICAL OCEANOGRAPHY CENTER
- WESTINGHOUSE ELECTRIC CORP.
- COMMANDER, NAVAL OCEANOGRAPHY COMMAND
- PAYLOAD TEST FACILITY

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3.2.2.4 Equipment Status Telemetry/Command Verification Requirements. Beginning with Spacecraft 9, the Equipment Status Telemetry/Command Verification link shall be encrypted. The Command Verification link shall support authentication. Prior Spacecraft have no such requirements. Space and ground resources encryption equipment interfaces are defined in Tables I and II. Further details on requirements concerning interfaces with and between this equipment is provided in CSESDs 10, 1, and 33.

3.2.3 Data Format Interface Requirements

3.2.3.1 Stored Data Format. The SD outputs from the OLS are recorded for later replay to the ground stations. The transmitted data rates shall be memory or ground commanded at either 1.3312 or 2.6624 Mb/s. The data streams normally represent one of the following: Light Fine (LF), Thermal Fine (TF), or bit-by-bit interleaved Light Smooth (LS) and Thermal Smooth (TS), or LF and TF. However, mixing of data types by time on a recorder is possible, although not normally done in operation. The smooth data recording formats include data blocks for Mission Sensor data and Equipment Status Telemetry occurring at the same time the smooth data is recorded. The telemetry shall be restricted to one of the 2 Kb/s modes when recording is desired. Stored data formats are specified in ICD-2617414.

3.2.3.2 Real-Time Data Format. The RTD output from the OLS at a data rate of 1.024 Mb/s for direct downlink contains either LF and TS or TF and LS data, selected by memory or ground command. It also contains mission sensor and Direct Mode Data Message (DMDM) data. The structure of RTD format is defined in ICD-2617415.

3.2.3.3. Commanding Data Format. Commands shall be uplinked at 2Kb/s (through S-15) and 10 Kb/s (S-16 through S-20) and shall consist of 25 bit words, except for authentication message sequence words which may be of varying lengths. Command data formats are specified in ICD-2617413.

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3.2.3.4. Equipment Status Telemetry Data Format. EST data shall be downlinked at either 2, 10, or 60 Kb/s and shall be stored for later playback when in the 2 Kb/s mode with SD recording in progress. EST formats are described in ICD-2617412.

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3.2.4 Data Definition and Calibration Requirements. The data definitions and calibration are more likely to be spacecraft specific due to the possibility of different sensor configurations and inherent differences in analog measurement properties between similar devices. The sensor calibration data is not treated in this document, since it is often not available until very late in the development process or may not be developed until on-orbit testing. The data definitions documentation should include adequate planning information for Ground Segment and operations concept development. Not all of the documentation identified in Table III is currently available, some will not be available for the earlier sensors. The Westinghouse (WEC) documents are internal (non-CDRL) data reduction guides. They are listed for completeness and typically are available only after joint OLS and mission sensor testing has started.

3.2.4.1 OLS Image and Parametric Data. The OLS image and parametric data content includes information on the bit weighting for the thermal (IR) channel, clocks, Nadir position, and

Table III. Data Format/Spacecraft Interfaces

Sensor/Spec \ Spacecraft	S-11 thru S-14	S-15	S-16 thru S-20
3-Way Spec	ICD-2617400	IS-DMSP-887	IS-DMSP-888
Spec "Tree"	ICD-2617401	ICD-2629941	IS-DMSP-88801
OLS	ICD-2617402	ICD-2629942	ICD-88802
SSBX-2	ICD-2617403	N/F	N/F
SSIES-2	ICD-2617404	ICD-2629944	ICD-88804
SSJ-4	ICD-2617405	ICD-2629945	ICD-88805
SSM	ICD-2617406	ICD-2629946	ICD-88803
SSMI	ICD-2617407	ICD-2629947	N/F
SSM/T-1	ICD-2617408	ICD-2629948	N/F
SSM/T-2	ICD-2617409	ICD-2629949	N/F
SSZ	ICD-2617411	N/F	N/F
SSMIS	N/F	N/F	ICD-88806
SSF	N/F	ICD-2629950	ICD-88807
SSY	N/F	N/F	ICD-88808
SSULI	N/F	N/F	ICD-88809
SSUSI	N/F	N/F	ICD-88810

NOTE: N/F = Not Flying [on that spacecraft]

sun/moon location. Calibration data includes sensor specific performance and telemetry curve fit coefficients. Applicable documentation, in addition to the appropriate space-to-ground ICD's is listed in Table III.

3.2.4.2. Mission Sensor Data. The Mission Sensor data content includes both information on sensor data bit weighting, and the structure of data within the sensor specific OLS data block. Calibration data includes sensor specific performance and telemetry curve fit coefficients. Mission sensor data formats for RTD and SD shall be as specified in ICD's 2617415 and 2617414, respectively. Further information is contained in the sensor peculiar ICD and WEC internal documents, if appropriate, listed in Table III.

3.2.4.3 Equipment Status Telemetry Data. The EST data content includes bit weighting and preliminary curve fit coefficients for all applicable telemetry points including analog, discrete and CPU. Calibration data includes spacecraft/sensor specific curve fit coefficients for those telemetry points which require accurate measurement.

Data definition and calibration data for specific spacecraft and their associated specific sensor complement are accumulated and documented in a spacecraft peculiar System Acceptance Test Report (SATR), i.e. SATR No. 10 for spacecraft 10. Additional specific and peculiar data definition/calibration will be accumulated during early orbit and the spacecraft operational lifetime.

SECTION 4. ACRONYMS AND ABBREVIATIONS

AF	Air Force
AFGWC	Air Force Global Weather Control
AFSCN	Air Force Satellite Control Network
AFVSF	Advanced Flight Vehicle Simulator Facility
ARTS	Automated Remote Tracking Station
ASE	Airborne Support Equipment
C ³	Command, Control and Communications
C3S	Command, Control and Communications Segment
CDRL	Contract Data Requirements List
CIU	Controls Interface Unit
CNOC	Chief Naval Oceanography Command
CMD	Command
Crypto	Cryptographic
CSESD	Communications Security Equipment Systems Document
CSOC	Consolidated Space Operations Center
CSTC	Consolidated Space Test Center
DMDM	Direct Mode Data Message
DMSP	Defense Meteorological Satellite Program
DMSP US	DMSP User Segment
DOMSAT	Domestic Satellite
EST	Equipment Status Telemetry
FNOC	Fleet Numerical Oceanography Center
FSOC	Fairchild Satellite Operations Center
GE/ASD	General Electric/Astro Space Division
GS	Ground Support
GSE	Ground Support Equipment
HTS	Hawaii Tracking Station
ICD	Interface Control Document
I/F	Interface
IR	Infrared
IS	Interface Specification
Kb/s	Kilobits per second
KG	Encryption/Decryption Devices
LF	Light-Fine (OLS Data Format)
LS	Light-Smooth (OLS Data Format)

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Mb/s	Megabits per second
MC	Marine Corps
MPSOC	Multi-Purpose Satellite Operations Center
NHS	New Hampshire (Tracking) Station
OLS	Operational Linescan System
PIP	Programmable Information Processor
PTF	Payload Test Facility
RF	Radio Frequency
RTD	Real-Time Data
RTS	Remote Tracking Station
SATR	System Acceptance Test Report
SD	Stored Data
SGLS	Space-Ground Link Subsystem
SPO	System Program Office
SS	System Specification
TBD	To Be Determined
TF	Thermal-Fine (OLS Data Format)
TOR	Technical Operating Report
TS	Thermal-Smooth (OLS Data Format)
TTS	Thule Tracking Station
US	User Segment
VTS	Vandenberg Tracking Station
WEC	Westinghouse Electric Corporation

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